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Le document présente le programme officiel de géologie pour les étudiants du secondaire IV et V des écoles publiques et privées du Québec. Il est destiné à tous les éducateurs intéressés à l'enseignement de la géologie et, plus particulièrement, aux professeurs de sciences naturelles qui sont chargés de donner ce cours. Le programme a été préparé par la Direction générale des programmes du MEQ en collaboration avec des conseillers et des professeurs du secondaire et du collégial. Il s'agit d'un programme commun pour tous les élèves. Il est de la responsabilité des directeurs d'écoles de planifier un système d'éducation qui permette de réaliser les objectifs du programme et, si nécessaire, de prévoir un enseignement enrichi, allant au delà du programme commun, pour les élèves doués. Le document comprend cinq parties: 1. l'introduction rappelle l'histoire du programme et situe ce cours en relation avec les autres cours; 2. les orientations du cours; 3. le contenu d'apprentissage; 4. les objectifs généraux du cours et de chaque module; 5. le mode d'évaluation.

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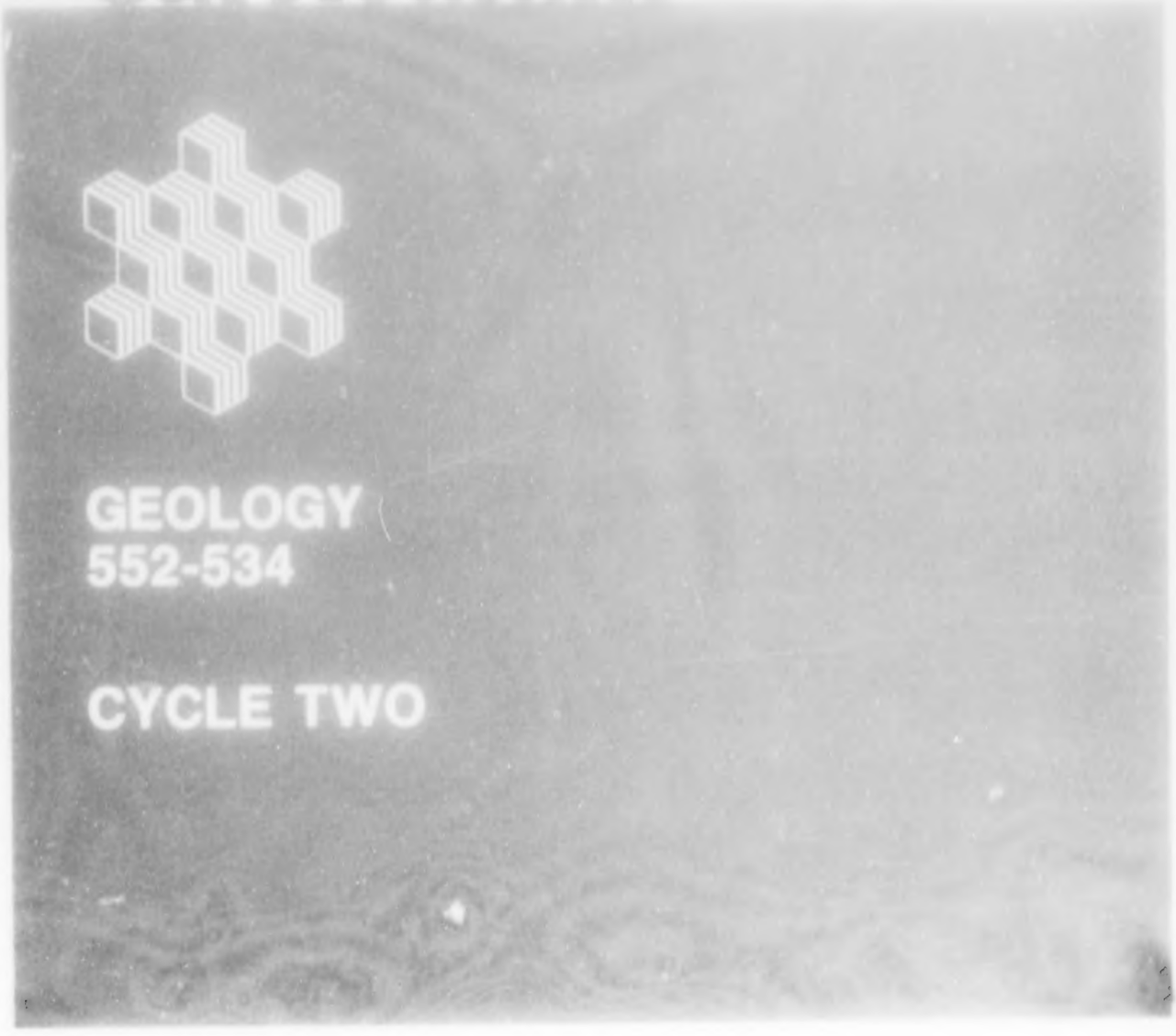
Secondary School Curriculum



GEOLOGY
552-534

CYCLE TWO

Quebec

EDUQ
0970098

Secondary School Curriculum

GEOLOGY
552-534

CYCLE TWO

Direction générale des programmes
Direction de la formation générale

This document was written by:
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This program, Geology *for levels four and five of secondary school, is issued in accordance with Section 3 of the* Regulation Respecting the Basis of Secondary School Organization. *It has been approved by the Comité catholique and the Comité protestant of the Conseil supérieur de l'éducation in conformity with the provisions of paragraph (e) of Section 22 of* An Act Respecting the Conseil supérieur de l'éducation *(RSQ. c. C-60). The use of this program has been authorized for the purpose of teaching* Geology *in all schools as of July 1st, 1987.*

Claude Ryan
Minister of Education

TABLE OF CONTENTS

		PAGE
1.	**INTRODUCTION**	1
	1.1 Historical Background	1
	1.2 Analysis of Needs	1
	1.2.1 The Present Situation	3
	1.2.2 The Targeted Objective	4
	1.3 Priority Needs	5
	1.4 Relationship with Other Courses and Programs	6
	1.4.1 Courses and Programs at the Secondary Level	6
	1.4.2 Courses and Programs at the College Level	6
2.	**ORIENTATIONS OF THE COURSE**	7
	2.1 Values Emphasized	7
	2.2 Fundamental Principles	8
	2.2.1 Cultural Principles	9
	2.2.2 Sociological Principles	10
	2.2.3 Didactic and Epistemological Principles	11
	2.3 Focus of the Geology Course	12
	2.3.1 The Geological Environment	14
	2.3.2 The Different Branches of Geology	14
	2.3.3 The Nature of Geology	15
	2.3.4 The Geological Method: The Process of Geological Inquiry	16
	2.4 Instructional Approach	20
	2.5 The Role of the Teacher	22
3.	**LEARNING CONTENT OF THE COURSE**	23
	3.1 Global Objective	23
	3.2 General Objectives	24
	3.3 Terminal Objectives	24
	3.4 Intermediate Objectives	24
	3.5 Classification of Terminal and Intermediate Objectives	24
	3.6 Learning Content	25
	3.7 Course Structure	25
	3.8 Content Structure of a Module	25

PAGE

4. OBJECTIVES OF THE GEOLOGY COURSE 27

4.1 Objectives Related to Attitudes 27

4.1.1 Intellectual Values 27
4.1.2 Social Values 27
4.1.3 Personal Values 27
4.1.4 Mesological Values 29

4.2 Module 1: Geomorphology 29

4.2.1 General Objective 29
4.2.2 Orientation 29
4.2.3 Content Structure 29
4.2.4 Learning Objectives 30

4.3 Module 2: Petrology 34

4.3.1 General Objective 34
4.3.2 Orientation 34
4.3.3 Content Structure 34
4.3.4 Learning Objectives 35

4.4 Module 3: Stratigraphy 40

4.4.1 General Objective 40
4.4.2 Orientation 40
4.4.3 Content Structure 40
4.4.4 Learning Objectives 41

4.5 Module 4: Global Tectonics 48

4.5.1 General Objective 48
4.5.2 Orientation 48
4.5.3 Content Structure 48
4.5.4 Learning Objectives 49

4.6 Module 5: Natural Resources 57

4.6.1 General Objective 57
4.6.2 Orientation 57
4.6.3 Content Structure 57
4.6.4 Learning Objectives 59

5. EVALUATION 64

5.1 Measurement 64

5.1.1 Selection of Measurement Instruments 64
5.1.2 Quality of Measurement Instruments 65

5.2 Criterion-Referenced and Norm-Referenced Evaluation 66

APPENDIX: TAXONOMY OF SPECIFICATIONS FOR SCIENCE EDUCATION BY BLOOM, HASTINGS AND MADAUS 67

Foreword

This document represents the official Geology program for secondary IV and secondary V students of the public and private schools of Québec. It is intended for all educators interested in the teaching of geology and, more specifically, for all secondary school natural science teachers who will be responsible for teaching the course. Also, directors of instructional services, general education coordinators and educational consultants in natural sciences may find this program useful when planning and conducting implementation and professional development workshops for the teaching of geology.

The program was prepared by the Direction générale des programmes du ministère de l'Éducation du Québec in collaboration with educational consultants and secondary school and CEGEP teachers; it prescribes a common-core curriculum for all students. It is the responsibility of the individual school boards to establish an educational system that supports the achievement of objectives and, when warranted, provides enriched instruction to gifted students capable of exceeding the common-core curriculum.

A curriculum guide based on the same principles accompanies this Geology program. The guide is intended as an optional teaching aid and contains suggestions for various teaching strategies; it also provides guidelines to methodology and references to supplementary documents. Furthermore, it specifies the conditions for the implementation of the program and provides a list of required course materials and equipment.

1. INTRODUCTION

1.1 Historical Background

In 1967, the Grade 11 Geology course was withdrawn as an optional course from the secondary school curriculum. Since then, students have been completing secondary school with virtually no knowledge of a science that could help them to discover and to appreciate certain natural phenomena and human realities.

Since 1967, several experimental efforts have been made to reintroduce geology to the students, particularly within the framework of extra-curricular activities. The results of these efforts indicated that the subject was very well received by students with a strong interest in their environment.

Recognizing that geology plays an important role in the scientific training of young minds, in 1979, the ministère de l'Éducation reinstated it as an optional course for Secondary IV and Secondary V students.[1] In November of the same year, a production committee was formed to develop a new geology program.

1.2 Analysis of Needs

In February 1980, the Direction générale du développement pédagogique administered a questionnaire[2] to assess the overall situation

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[1] Québec, ministère de l'Éducation, **The Schools of Québec - Policy Statement and Plan of Action** (Québec: Service général des communications du ministère de l'Éducation, 1979).

[2] Québec, ministère de l'Éducation, Direction générale du développement pédagogique, **Questionnaire-sondage à l'intention des enseignants en sciences de la nature avec expérience passée ou présente de l'enseignement des sciences de la Terre (géologie)** (Québec: ministère de l'Éducation, February 1, 1980).

1.2 Analysis of Needs (cont'd)

and the availability of resources regarding the teaching of geology and to determine the content and orientations of the new geology program to be developed. This questionnaire was based on recommendations made by universities in a report on the teaching of Earth Sciences at the secondary level, and on recommendations made by CEGEP teachers and the Groupe de l'enseignement des sciences de la Terre (G.E.S.T.).

Over the past decade, numerous other studies have been carried out on the teaching of sciences. Among them are the Evalensci Report,[1] the ASOPE study,[2] the orientation project of the Direction générale du développement pédagogique,[3] a paper by the Association des professeurs de sciences du Québec,[4] a study by Jacques Desautels[5] and, more recently, a report by the Science Council of Canada.[6] These reports served as guidelines for the program development team in establishing the orientations and underlying premises of the program.

---

1 Louis Sainte-Marie et al., **Évaluation de l'enseignement des sciences au secondaire**, Progress Report, 1976.

2 Pierre W. Bélanger and G. Rocher, **Aspirations scolaires et professionnelles des étudiants**, Paper presented at the Learned Societies Conference in Montréal, May 23 and June 5, 1976.

3 Québec, ministère de l'Éducation, **Projet d'orientation de l'education scientifique au niveau secondaire au Québec**, Phase 1, Working Paper, October 1978; Phase 2, Working Paper, December 1978.

4 Association des professeurs de sciences du Québec, **Mémoire sur le Livre vert de l'enseignement primaire et secondaire au Québec**, May 1978.

5 J. Désautels, **École + Science = Échec** (Québec: Québec Science Éditeur, 1980).

6 The Science Council of Canada, **Science for Every Student - Educating Canadians for Tomorrow's World**, Report 36 (Hull: Canadian Government Publishing Centre, 1984).

1.2.1 The Present Situation

The results of the 1980 survey revealed that the teaching of geology was virtually non-existant in Québec's secondary schools, and that few of the teaching staff had any formal training in the subject. The few schools that were offering some geology-related activities were facing problems such as insufficient and inadequate materials, high student-teacher ratios and awkward time schedules, making field trips difficult, if not altogether impossible.

Curiously, the only means for students to acquire some knowledge pertaining to geology was by studying physical geography. In September of 1986, Secondary II students gained another opportunity to learn about certain geological principles by means of a problem-solving process presented in the "Rocks and Minerals" module of the Physical Science program (Physical Environment, document 16-3174).

Various studies conducted over the past twelve years on the teaching of sciences in the province of Québec indicate that the discipline has not achieved its own objectives. According to these studies, students have not acquired any real scientific knowledge; more particularly, they have failed to familiarize themselves with the scientific method or to assimilate any integrating concepts. Moveover, students tend to have an almost blind faith in the intellectual and moral value of science.

In the same vein, a 1978 study headed by the Direction générale du développement pédagogique revealed that only one third of the province's engineers were from Québec.[1]

---

1 Québec, ministère de l'Éducation, **Questionnaire-sondage**, 1980.

1.2.1 The Present Situation (cont'd)

A more recent study by the Science Council of Canada established that the province of Québec is lagging far behind in the development of advanced industrial materials such as ceramics, composites, metals and polymers.[1] Without laying the blame on anyone in particular, it appears that the responsibility lies with the province's economic and educational systems.

1.2.2 The Targeted Objective

The general conclusion of the above-mentioned studies, as upheld by the provincial government's green papers on education and recreation, is that measures must be taken to promote an interest among Québecers in their environment. Geology provides a good way to discover a view of Québec that is often ignored, yet has much to offer. The content and the instructional approach for teaching this subject should, however, reflect the interests and abilities of the young people concerned, not all of whom will necessarily become geologists.

Thus, the objective in teaching geology is to enable students to expand their field of knowledge, to gain a better understanding of their geological environment and to learn to use it rationally. Furthermore, the study of geology should help students to acquire a method of scientific inquiry and to prepare them for an active and contributing role in society. Findings show that the most effective approaches to achieving these goals are field and laboratory investigations which emphasize observation and

---

1 The Science Council of Canada, **Advanced Industrial Materials: Canadian Perspectives and Opportunities.** Discussion Paper on workshops held in Montréal in fall of 1984, (Hull: Canadian Government Publishing Centre, May 1985).

1.2.2 The Targeted Objective (cont'd)

experimentation. These findings further indicate that topics of study for a geology course should focus on relatively concrete phenomena, and that subjects of a more abstract nature should be avoided. Accordingly, suggestions for possible topics of study have been submitted by qualified consultants.

1.3 Priority Needs

The situation described above called attention to a need for developing a new geology course to satisfy the interests and requirements of young Québecers in the fifteen- to sixteen-year-old age group. The previously mentioned report by Québec universities on the teaching of earth science at the secondary level had already recommended that the American method, Earth Science Curriculum Project (ESCP), be adopted and applied in our schools. However, this methodology, while admittedly an excellent one, is inappropriate for our purposes; it is aimed primarily at pre-university students in order to quickly and effectively fill the quota of required scientists. As for the geology courses offered in Canadian provinces outside of Québec, most are a conglomeration of themes borrowed from historical, structural, general and applied geology, as well as petrology, meteorology, climatology and even oceanography.

The new geology course must take into consideration three important needs identified in the survey and the afore-mentioned studies, namely:

- the need to give priority to reaching all the students concerned and to stimulate their interest;
- the need to select learning objectives that incorporate concrete situations which are likely to raise questions in the minds of the students;

- the need to give young people the opportunity to develop an interest in and an awareness of the geology of Québec.

1.4 Relationship with Other Courses and Programs

1.4.1 Courses and Programs at the Secondary Level

By studying the Ecology, Physical Science (Physical Environment), Biology, Chemistry and Physics programs, students have been gradually introduced to the intellectual process associated with the scientific method. Similarly, in the "Rocks and Minerals" module of the Physical Science (Physical Environment) program, students were introduced to certain geological concepts. Students also had an opportunity to gain some knowledge related to geology in the Secondary I and Secondary III Geography courses, particularly in the content pertaining to "geomorphology."

The new Geology course is designed to strengthen students' skills and attitudes associated with the scientific method, and to satisfy their curiosity regarding this specific field of knowledge. The approach encourages students to apply the geological method in order to build their knowledge of the local geological environment.

1.4.2 Courses and Programs at the College Level

The secondary school second-cycle Geology course gives students the opportunity to expand their general knowledge; students enrolled in this course will be better qualified to select a curriculum that is suited to their particular interests and abilities. Having acquired the work method and the knowledge related to this course, students will be better equipped to meet the demands of science courses at the college level.

2. ORIENTATIONS OF THE COURSE

2.1 Values Emphasized

Section 1.2 on the analysis of needs identified the educational values which this program strives to uphold; in so doing, the program tries to make its own unique contribution to implementing the Plan of Action set forth in **The Schools of Québec.**[1] These values, listed below, concern the person's intellectual, emotional, aesthetic, mesological (in this context, relating to the moral, spiritual and religious), as well as social and cultural development.

1. A sense of methodical work and a constant seeking after truth.

   - These intellectual values are acquired through the precision of experimentation, model construction, observation, analysis and by formulating hypotheses based on observation.

   - Through the study of global tectonics, the student can acquire the conceptual elements necessary for understanding such natural phenomena as earthquakes, which were previously regarded as inexplicable disasters.

2. An open attitude towards things so as to discover their nature and diversity.

   - Field trips are an essential feature of this geology course, for they enable the student to get in touch with nature, to discover the transformations which have occurred in the environment and to develop a certain affinity to the local region.

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[1] Québec, ministère de l'Éducation, **The Schools of Québec - Policy Statement and Plan of Action**, (Québec: ministère de l'Éducation, 1979), pp. 27-28.

3. The ability to appreciate beauty, which may be developed by contemplating nature.

   - Among other things, geology enables the student to discover the charm of natural landscapes, the colours and structures of the mineral world and the delicate life forms represented by fossils. The appreciation of natural phenomena will gradually lead the student to seek greater harmony with the environment.

4. An appreciation of Québec's heritage.

   - By discovering Québec's geological environment, the student will be able to develop a greater awareness of the province's natural resources and appreciate the value of forming a concerned society in which these resources are used for the common good.

5. Respect for the environment.

   - By being encouraged to recognize and to reflect on both the consequences of a wasteful economy within technologically advanced societies and the invasion of the person's inner and external space, the student will begin to develop a conservationist attitude towards natural resources and to behave accordingly.

2.2 Fundamental Principles

This course tries to provide young people with a further opportunity to satisfy their need to interact with nature and their immediate environment, and to become aware of certain geological phenomena. The course is based on the most recent data on the recommended instructional approach to natural science.

2.2.1 Cultural Principles

A person's culture is the end product of the multiple learning experiences of that individual in the process of maximizing personal development. A government study on cultural policy entitled **La politique québécoise du développement culturel**[1] emphasizes that it is difficult to deny the relationships which exist between science and culture.

A person's basic scientific knowledge is all the more complete if it encompasses a wide spectrum of fundamental concepts underlying the scientific disciplines which serve to sustain a nation's growth and future development. In terms of cultural value, the study of geology imparts an understanding of the Earth's formation and its evolutionary process. It offers young Québecers the means and opportunities to discover their physical environment, to develop a favourable attitude towards a constructive application of scientific knowledge and to become aware of the problems confronting modern science.

The general educational objectives put forward by the Governement of Québec stipulate that, upon completing the second cycle of secondary school, students should possess an expanded sphere of scientific knowledge acquired through the study of biology, chemistry, geology and physics. The Green Paper on recreation in Québec[2]

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[1] Gouvernement du Québec, Le ministère d'État au Développement culturel. **La politique québécoise du développement culturel**, Volume 2, (Québec: Éditeur officiel du Québec, 1978), p. 268.

[2] Gouvernement du Québec, Haut-Commissariat à la jeunesse, aux loisirs et aux sports, **Prendre notre temps**; Green Paper on Recreation in Québec (Québec: Service des communications, 1977), p. 64.

(which was subsequently issued in the form of a White Paper) also voices this concern and stresses the importance of giving back Québecers the means and opportunities to satisfy the need to have contact with nature or simply to learn to appreciate it.

2.2.2 Sociological Principles

Geology is more than a body of knowledge of theoretical interest (as pure science). It is also an applied science which is gaining prominence in today's society and economy. Geologists fulfill an important function in society; their professional activities include, among others:

- prospecting for mineral deposits;
- overseeing mining operations;
- implementing major projects such as building dams, roads and bridges;
- working to predict natural disasters such as earthquakes, volcanic eruptions and landslides.

In order to ensure its progress and future, an industrial society must have natural resources and the skilled manpower necessary for their exploitation. Few countries in the western world are as rich in natural resources as is the province of Québec. However, Québec has yet to fully develop the expertise and the human resources that are necessary to sustain a satisfactory level of industrial activity in this sector.

In order to develop a contingent of qualified, socially conscious scientists, Québec must foster a genuine interest in geology among its people. One way to help achieve this goal is to place young Québecers in contact with their immediate physical environment. Furthermore, it should be recognized that school plays an important role in shaping young people's attitudes towards science and technology, as well as in directing their aspirations to scientific careers.

The growth of a population cannot be assured unless each individual is made aware of the dangers posed by the wasteful depletion of non-renewable resources and damage to the environment. Through their daily activities, students should gradually develop an affirmative attitude towards the conservation of natural resources, and this attitude should consequently translate into concrete action. As responsible citizens, they will increasingly view themselves as individuals contributing to the common good.

Based on the above sociological principles, this Geology course favours an approach that is adaptive to the problems of today. Such an approach involves a constant striving towards maintaining a harmonious relationship between human beings and their environment, and their economic and technological affairs. Teachers are called upon to make every effort towards rendering the geology of Québec more relevant to the daily lives of young Québecers.

2.2.3 Didactic and Epistemological Principles

In order to have meaningful learning experiences, students must actively participate in their acquisition of knowledge. To achieve this goal teachers should respect

the student's level of learning readiness (stages defined according to "genetic epistemology,"[1] prior learning, personal interests, etc.) and try to facilitate the student's contact with reality. Secondary school is a time for exploration rather than specialization.

Teachers should therefore adopt the kinds of strategies that will initiate conceptual changes within the student. These changes can occur only during a state of disequilibrium in the cognitive structures,[2] when all learning is called into question. Furthermore, the changes will be effective only to the extent that they are meaningful and hold interest for the student; consequently, they can only be achieved over the long term, after considerable trial and error.

With the help of the teacher, and on their own, students have the potential to build their knowledge of their geological environment. Teaching of the Geology course should therefore be organized in a manner that will encourage students to apply the problem-solving process, rather than merely absorb knowledge passively.

2.3 Focus of the Geology Course

The focus of this course is the geological environment and the geological method. These two dimensions are integrated in the course objectives, taking the students' needs and abilities into consideration as much as possible. The geological method should be incorporated in the learning activities that are chosen to help students discover their geological environment.

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[1]Charles J. Brainerd, **Piaget's Theory of Intelligence** (Eaglewood Cliffs: Prentice-Hall Inc., 1978), p.16

[2]Brainerd, **Piaget's Theory**, p.20.

Figure 1

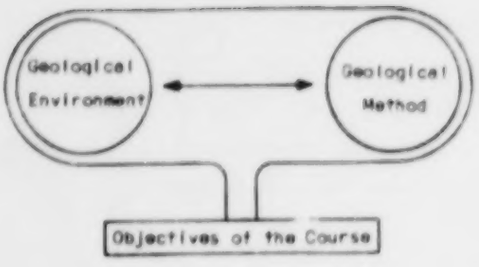
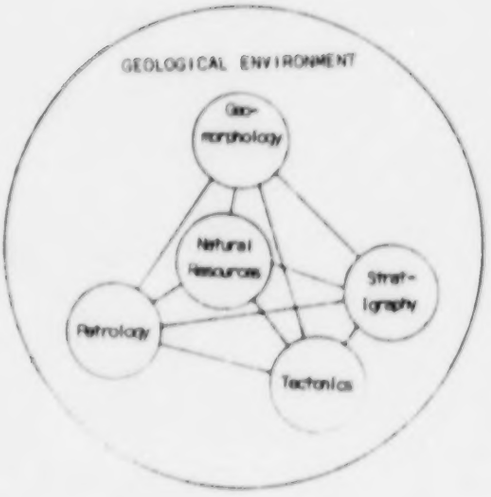


Diagram 1

Figure 2



Basic Concepts

2.3.1 The Geological Environment

No matter where people go, they are always in contact with one or more elements of the geological environment, such as:

- the asphalt and gravel of a road;
- traffic signals (paint and signposts);
- roadside ditches exposing layers of rock that reveal their formation, history and erosion;
- building materials at construction sites;
- industrial materials;
- landscapes;
- motor fuel (exhaust from cars);
- other

Together, these elements constitute the geological dimension of the environment (see Figure 1) which is the basis of study of the different branches of geology.

2.3.2 The Different Branches of Geology

Each of the preceding elements falls under one or more of the specific branches of geology, among them:

- geomorphology, which relies on tectonics and petrology and focuses on the study of landforms and the processes of their development;
- stratigraphy, tectonics and petrology, all of which are involved in prospecting for natural resources;
- mining and the exploitation of natural resources which serve to build and to develop industry, etc.

This Geology course is based on the study of geomorphology, petrology, stratigraphy, tectonics and natural resources. These five topics, together with the study of the geological environment, constitute the focus of learning for this course.

2.3.3 The Nature of Geology

Geology is a science which deals with the study of the Earth. It studies the Earth's crust, structure and composition and, like all sciences, tries to explain the different phenomena that are constantly shaping the Earth's surface. Rock may seem to be eternal, but the Earth is constantly changing.

The five branches of this Geology course use various mechanisms borrowed from other scientific disciplines to interpret terrestrial phenomena. For example, geomorphology incorporates physical geography; petrology combines physics and chemistry; stratigraphy uses physics; chemistry uses biology; tectonics integrates geometry and physics; the study of natural resources incorporates physics, chemistry, biology and various technologies.

As a discipline, geology involves field work and tries to retrace the Earth's history by observing structural features that have been formed in the past. Geologists, therefore, carry out research both in the field and in the laboratory. Occasionally, their work is comparable to that of historians.

2.3.4 The Geological Method: The Process of Geological Inquiry

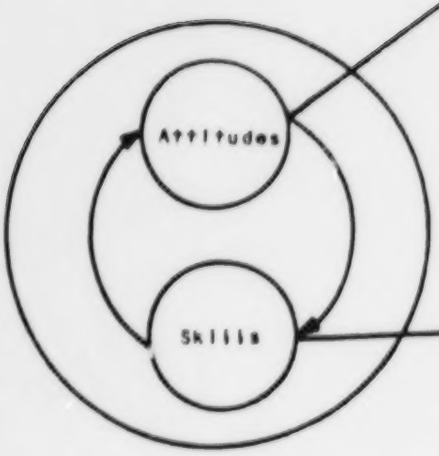
As field workers, geologists make observations and take measurements for mapmaking. They must be geomorphologists, petrographists, stratigraphists, tectonists and prospectors, all at the same time.

As historians, geologists try to understand what has occurred in the past and attempt to foresee what is likely to occur in the future. In developing their understanding, they interpret phenomena and create models which in turn lead them to formulate theories. These theories enable them to anticipate events such as earthquakes and volcanic eruptions.

When studying a geological environment, geologists use a procedure specific to their field called the geological method. This method of scientific inquiry, described and illustrated in Figure 3, resembles the problem-solving process and involves the type of skills and attitudes that are associated with the values described in Section 2.1.

Figure 3

THE GEOLOGICAL METHOD



ATTITUDES

- intellectual: sense of
  - curiosity
  - objectivity
  - creative spirit
  - critical spirit
  - investigative approach
- social: openness towards others
  - tolerance
- personal: self-confidence
  - perseverence
  - prudence
  - acceptance of the geological method
- mesological: respect
  - responsibility

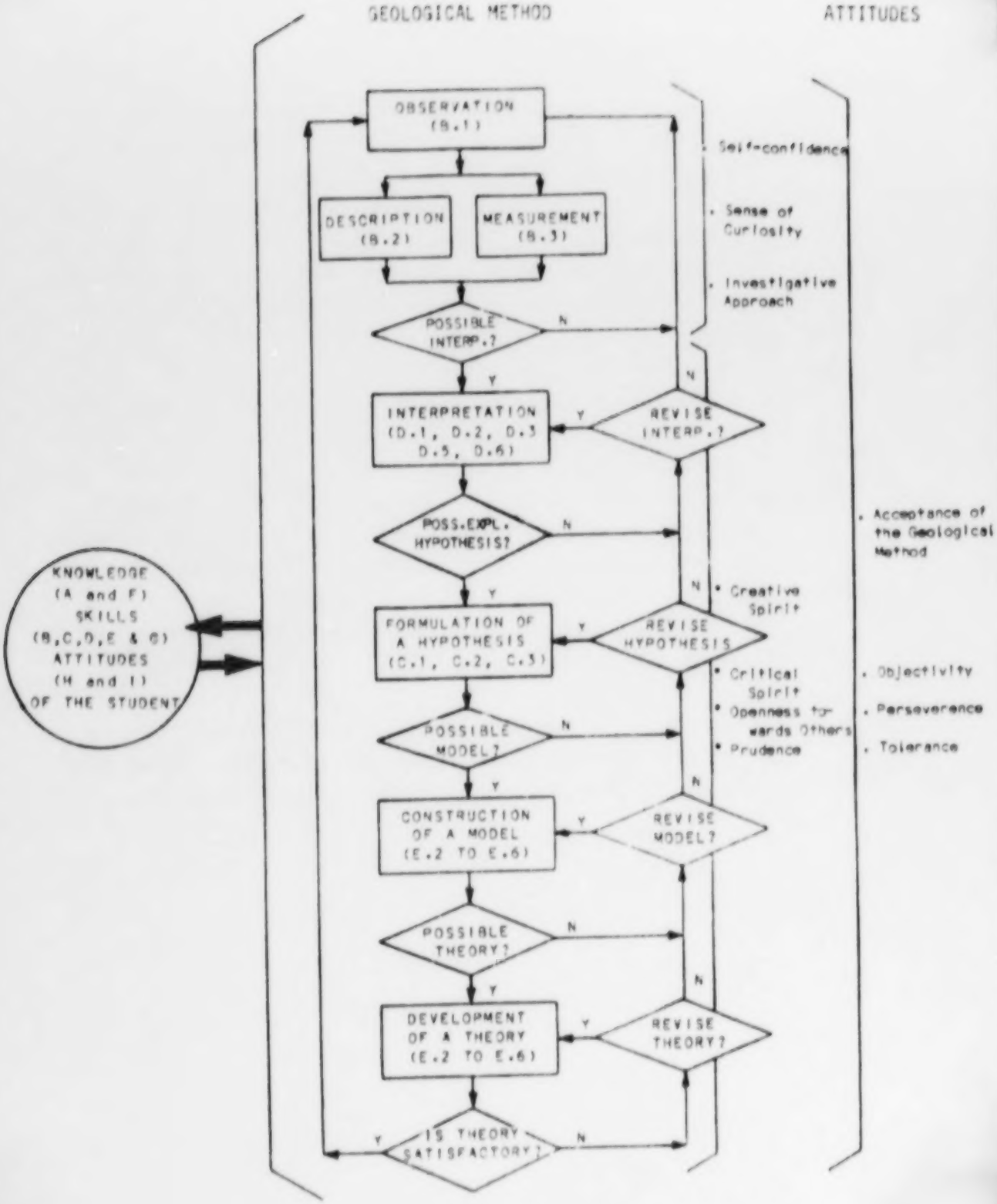
SKILLS

- observation
- description
- measurement
- interpretation of phenomena
- hypothesis formulation
- model construction
- theory development

It is difficult to identify all the skills which come into play when applying the geological method. Nevertheless, geologists generally observe, describe, measure and interpret phenomena, formulate hypotheses, construct models and develop theories. As illustrated in Figure 4, these skills may be organized according to a specific process (indicated by the various return loops) which is adaptable to the numerous situations generally encountered in the study of the geological environment.

In carrying out their learning activities, during which they will be applying the geological method, students will also have the opportunity to develop or perhaps to modify certain attitudes. Figure 3 lists the principal attitudes which students will be able to improve in this course, arranged in four (4) categories. In Figure 4, these same attitudes are linked with the most closely corresponding skills associated with the geological method.

Figure 4


GEOLOGICAL METHOD
ATTITUDES
OBSERVATION (B.1)
DESCRIPTION (B.2)
MEASUREMENT (B.3)
POSSIBLE INTERP.?
N
Y
INTERPRETATION (D.1, D.2, D.3 D.5, D.6)
Y
REVISE INTERP.?
N
POSS.EXPL. HYPOTHESIS?
N
Y
FORMULATION OF A HYPOTHESIS (C.1, C.2, C.3)
Y
REVISE HYPOTHESIS
N
POSSIBLE MODEL?
N
Y
CONSTRUCTION OF A MODEL (E.2 TO E.6)
Y
REVISE MODEL?
N
POSSIBLE THEORY?
N
Y
DEVELOPMENT OF A THEORY (E.2 TO E.6)
Y
REVISE THEORY?
N
IS THEORY SATISFACTORY?
Y
N
KNOWLEDGE (A and F) SKILLS (B,C,D,E & G) ATTITUDES (H and I) OF THE STUDENT
. Self-confidence
. Sense of Curiosity
. Investigative Approach
. Acceptance of the Geological Method
• Creative Spirit
• Critical Spirit
• Openness towards Others
• Prudence
. Objectivity
. Perseverence
. Tolerance

2.4 Instructional Approach

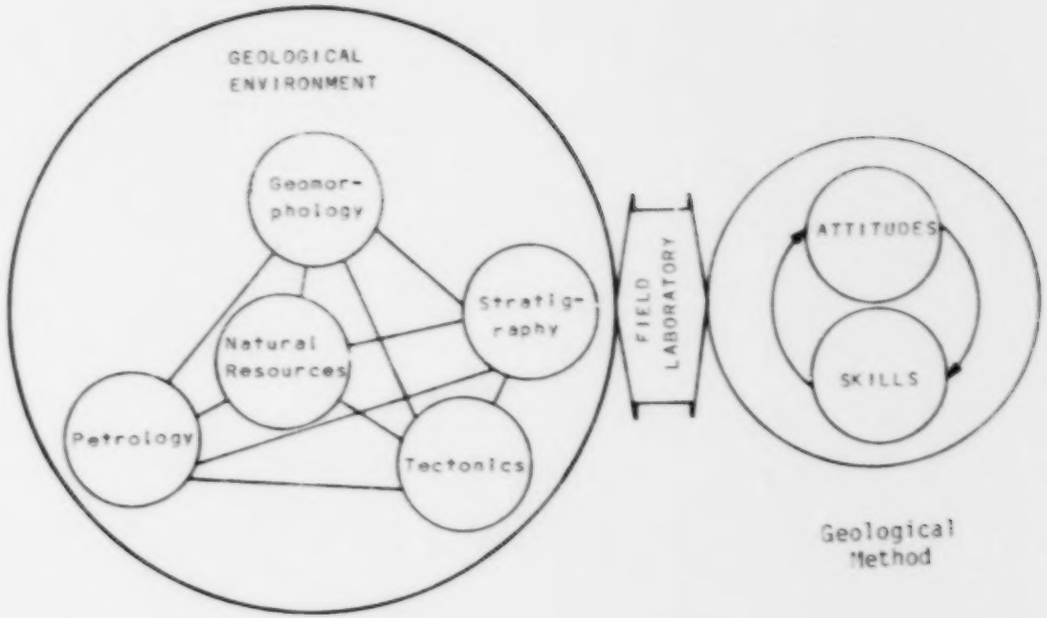
The recommended instructional approach, illustrated in Figure 5, is in keeping with the previously defined pedagogical principles and is based on a combination of field work (field trips) and laboratory studies. Teachers are encouraged to select the type of learning situations that will place students in direct contact with their immediate geological environment; such situations will afford students the opportunity to apply and to become familiar with the geological method.

As illustrated in Figure 4, students will approach the study of the geological environment and gradually master the geological method by transferring what they have previously learned (knowledge, skills, attitudes) at home or at school. The selected learning activities should serve to motivate students to apply and to enrich their previous learning. In due time, students will have to modify some of the acquired knowledge, skills and attitudes in their cognitive structures when these fail to meet the requirements of their new learning activities.

In the case of certain phenomena which cannot be observed in the field or in the laboratory, teachers may substitute films or other audio-visual materials to complete the students' learning.

Figure 5

INSTRUCTIONAL APPROACH



2.5 The Role of the Teacher

On the basis of the previously defined pedagogical principles, the teacher should guide the students through their learning process and select the learning situations that are most likely to: encourage the students' awareness of certain geological realities, promote their interaction with the environment and foster a state of disequilibrium in the cognitive structures.[1] The teacher then assists them in collecting and evaluating relevant information and, lastly, provides feedback to help them assess and synthesize what they have learned.

The teacher's role therefore is to plan the learning activities, to help students carry them out and to evaluate the students' learning. Given that this is a science course, the selected activities should stress the study of realistic situations and experimental research, whenever possible. The teacher should strive to create a learning environment that will help students to develop the skills and attitudes associated with the geological method (the method of scientific inquiry), which goes beyond the simple implementation of a given experimental procedure.

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[1] Brainerd, **Piaget's Theory of Intelligence**, p. 20.

3. LEARNING CONTENT OF THE COURSE

3.1 Global Objective

Geology plays an increasingly important role in today's world and economy. Consequently, the intention of this optional course is to enrich the students' scientific knowledge by helping them to develop an awareness of certain geological phenomena related to their immediate environment, using a method which is similar to that applied by geologists. This global course objective is in keeping with the established framework of the general goals of education as defined in **The Schools of Québec.**[1]

Goals

The purpose of this course, in line with the afore-mentioned objective, is to provide the type of learning content that will help students:

(i) to acquire the basic concepts related to geomorphology, petrology, stratigraphy, global tectonics and the natural resources found in their immediate environment;

(ii) to gradually acquire a work approach by applying the geological method to explore the various natural phenomena encountered in their geological environment;

(iii) to develop a sense of responsibility and a critical spirit regarding the use of geological resources for their personal benefit and for the benefit of humankind.

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[1] Québec, ministère de l'Éducation, **The Schools of Québec**, 1979, Chapt. 2.

3.2 General Objectives

Based on the results of the previously-mentioned questionnaire and the experts' recommendations, five modules were selected for the course, corresponding to five branches of geology. Each of these modules is governed by a general objective which reflects the spirit of the questionnaire and the afore-mentioned studies, and respects the aims and global objective of the course.

3.3 Terminal Objectives

The terminal objectives of each module state the general objective of the course in more specific terms. They are formulated in terms of the skills and attitudes associated with the geological method as well as the body of knowledge related to geology. The terminal objectives are the only **compulsory** feature of the course.

These objectives are organized in a logical sequence. However, they may be rearranged to suit any order of instruction.

3.4 Intermediate Objectives

Each terminal objective is followed by a set of intermediate objectives. These too are arranged in a logical sequence intended to help students reach the terminal objectives. Intermediate objectives are optional, however, and are offered as suggestions only. They may be adapted according to the teacher's personal initiative and the regional characteristics of the school.

3.5 Classification of Terminal and Intermediate Objectives

The learning objectives have been classified according to the taxonomy of educational objectives by Bloom, Hastings and Madaus.

Categories A and F apply to knowledge and comprehension and are associated with the first of the three goals described in Sec. 3.1. Categories B, C, D, E and G relate to skills and are associated with the second goal, while categories H and I concern attitudes and are associated with the third goal.

3.6 Learning Content

Adjacent to the intermediate objectives is the learning content. It should be regarded as supplementary information specifying the knowledge and some of the skills and attitudes associated with the intermediate objectives. This information is provided to help teachers determine their educational approach; as with the intermediate objectives, the learning content is offered as a guide only.

3.7 Course Structure

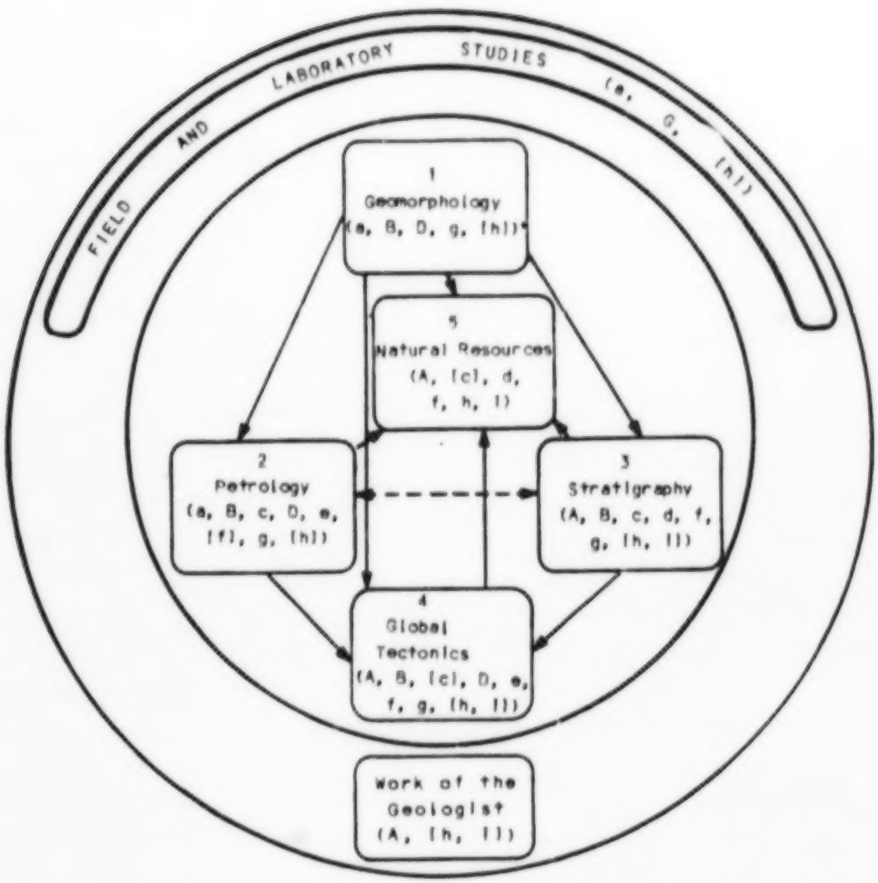
The course comprises five modules. Each module is organized according to a progressive sequence of learning based on related content and covers the full range of categories of Bloom, Hastings and Madaus' taxonomy of educational objectives. The categories and subcategories of this taxonomy are summarized in the Appendix.

The course structure, illustrated in Figure 6, is also in keeping with the recommended instructional approach.

3.8 Content Structure of a Module

The content of each module is structured in a logical, hierarchical sequence. This structure serves to explain and define all of the content associated with the learning objectives. The content structure applicable to each of the five modules is subsequently incorporated in the curriculum guide. Only the first two levels of content structure are presented in the program, namely, those relating to general and terminal objectives.

Figure 6



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* Categories dealt with in a module. For example, in module 1 on Geomorphology, upper-case "B" represents a principle category, lower-case "a" represents a secondary category, and character "h" in parentheses "[h]" indicates a category which is related to the principle categories.

4. OBJECTIVES OF THE GEOLOGY COURSE

Section 4.1 outlines the attitude-related objectives associated with the terminal and intermediate objectives of the five modules. Each module is then dealt with separately, and is presented in order of the general objective, the module's underlying philosophy or orientation, the content structure, and, lastly, the terminal and intermediate learning objectives and their related learning content (knowledge, skills, attitudes).

4.1 Objectives Related to Attitudes

4.1.1 Intellectual Values

a) To show curiosity when carrying out field work or laboratory studies.
b) To display an investigative approach in field work and laboratory studies.
c) To manifest objectivity when applying the geological method.
d) To display a critical approach when interpreting various geological phenomena.
e) To display creativity when interpreting various geological phenomena.

4.1.2 Social Values

a) To display an openness towards others when interpreting various geological phenomena.
b) To exercise tolerance when applying the geological method.

4.1.3 Personal Values

a) To gain self-confidence by carrying out field work and laboratory studies.
b) To show perseverence when applying the geological method.
c) To exercise prudence when interpreting various geological phenomena.
d) To adopt the geological method as a means of interpreting geological phenomena and solving related problems.

4.1.4 Mesological Values

a) To develop a respectful attitude towards the geological environment when carrying out field work.

b) To adopt responsible behaviour towards the geological environment and towards the natural resources extracted from it.

4.2 Module 1: Geomorphology

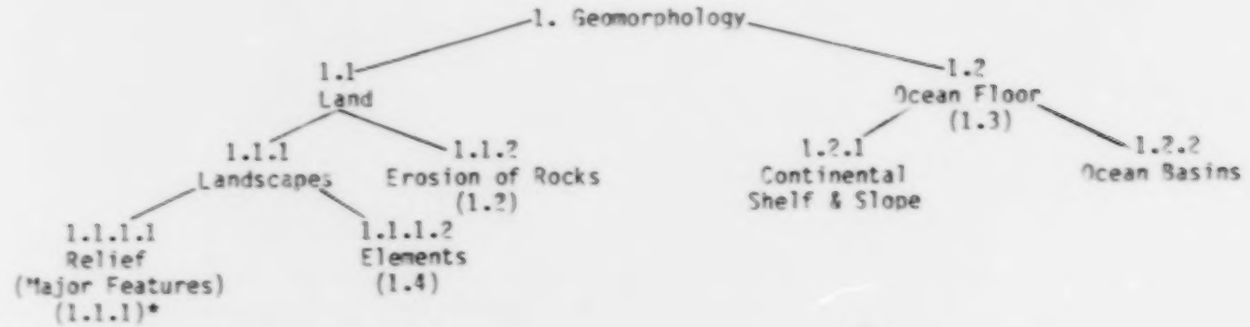
4.2.1 General Objective

1. TO EXPLAIN the relief of a landscape in terms of rock erosion.

4.2.2 Orientation

Geomorphology describes the relief features of land (continental crust) and ocean floor surfaces; it explains landscapes by discussing the eroding agents that have contributed to their formation. These descriptions are made on the basis of field observations and the interpretation of topographic and bathymetric maps and aerial photographs.

4.2.3 Content Structure



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* These codes refer to the general and/or terminal objectives associated with the related content.

4.2.4 Learning Objectives

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 1.1 **To describe** the relief of a landscape in terms of its landforms (B.2).*		Interpreting	Objectivity
a) **To name** the major landforms of a landscape (A.2).	Landforms: mountain ridges, hills, valleys, depressions, terraces, cliffs, plains		
b) **To construct** a topographic map of a particular landform (B.3, D.1, G.2).	Topographic map	Measuring Interpreting Developing technique	Self-confidence
c) **To draw** a topographic profile of the relief of a landscape based on the information given on a topographic map (D.2 and G.1).	Topographic profile	Interpreting Developing dexterity	Investigative approach
d) **To identify** major landforms on a topographic map and a topographic profile. (D.3).		Interpreting	Critical spirit
e) **To analyze** a topographic map to obtain the information needed to describe the relief of a landscape (D.3).		Interpreting	Critical spirit
f) **To examine** the relief of a landscape from a specific vantage point in order to identify the particular landforms (B.1).	Relief of a landscape	Observing	Sense of curiosity
g) **To compare** the relief of a landscape as it appears from a specific vantage point with the way it is represented on a topographic map, in order to be able to locate his/her position on land. (A.4).	Relief shown on a topographic map**		

* The code refers to the taxonomy of specifications for science education by Bloom, Hastings, and Madaus. (See Appendix)

** Knowledge or skills which are underlined are associated with more than one learning content.

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
h) **To compare** the relief of a landscape as seen from a specific vantage point with the way it appears on an aerial photograph in order to be able to locate his/her position on land (A.4).	Aerial photography		
i) **To examine** the relief of a landscape on a pair of aerial photographs (stereographs) using a stereoscope in order to identify its landforms (B.1).	Stereoscope	Observing Developing technique	Sense of curiosity
j) **To compare** the relief of a landscape as it appears on a pair of aerial photographs with the way it is represented on a topographic map (A.4).			
k) **To describe** the major landforms of a landscape (B.2).		Describing	Investigative approach
T.O. 1.2 **To explain** how rocks are eroded by running water, wind, glacier ice and the sea (D.6).		Interpreting	Acceptance of the geological method
a) **To observe** the erosion of rocks comprising the various lithological elements of a landscape (B.1).	Erosion of rocks	Observing	Sense of curiosity
b) **To experiment** with the erosional effects of running water in a laboratory (B.3 and G.1).	Erosion by running water	Measuring Developing dexterity	Sense of curiosity

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
c) **To describe** erosion by running water (B.2).		Describing	Objectivity
d) **To observe** the erosional effects of running water in the field, or in a laboratory (B.1).	Effects of erosion by running water	Observing	Sense of curiosity
e) **To describe** wind erosion. (B.2).	Wind erosion	Describing	Objectivity
f) **To observe** the effects of wind erosion in the field (B.1).	Effects of wind erosion	Observing	Sense of curiosity
g) **To describe** erosion by glacier ice (B.2).	Erosion by glacier ice	Describing	Objectivity
h) **To observe** the effects of glacial erosion in the field (B.1).	Effects of glacial erosion	Observing	Sense of curiosity
i) **To describe** erosion by sea waves (shoreline erosion) (B.2).	Erosion by waves (shoreline erosion)	Describing	Objectivity
j) **To observe** the effects of shoreline erosion on film, or in the field (B.1).	Effects of shoreline erosion	Observing	Sense of curiosity
T.O.1.3 **To describe** marine geomorphology using a bathymetric map and a map of the ocean floor (D.3).	Marine geomorphology	Interpreting	Critical spirit Prudence
a) **To compare** a bathymetric map with a topographic map of the ocean floor (D.3).	Bathymetric map	Interpreting	Critical spirit

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
b) **To identify** landforms in the continental shelf and continental slope on a bathymetric map (D.3).	Continental shelf and continental slope landforms: plateaus, talus slopes, canyons	Interpreting	Critical spirit
c) **To describe** landforms in the continental shelf and continental slope using a bathymetric map and a profile (B.2).		Describing	Investigative approach
d) **To identify** the main features of the ocean basin on a map of the ocean floor (D.3).	Landforms of the ocean basin: mid-ocean ridges plains, trenches	Interpreting	Critical spirit
e) **To describe** the landforms of the ocean basin using a map of the ocean floor (B.2).		Describing	Investigative approach
T.O.1.4 **To identify** features of a landscape which are associated with specific kinds of landforms (D.3).		Interpreting	Critical spirit Prudence
a) **To name** the major features of a landscape (A.3).	Features of a landscape: lithological, structural, climatic		
b) **To associate** the features of a landscape with various kinds of landforms (B.1).		Observing	Investigative approach Sense of curiosity

4.3 Module 2: Petrology

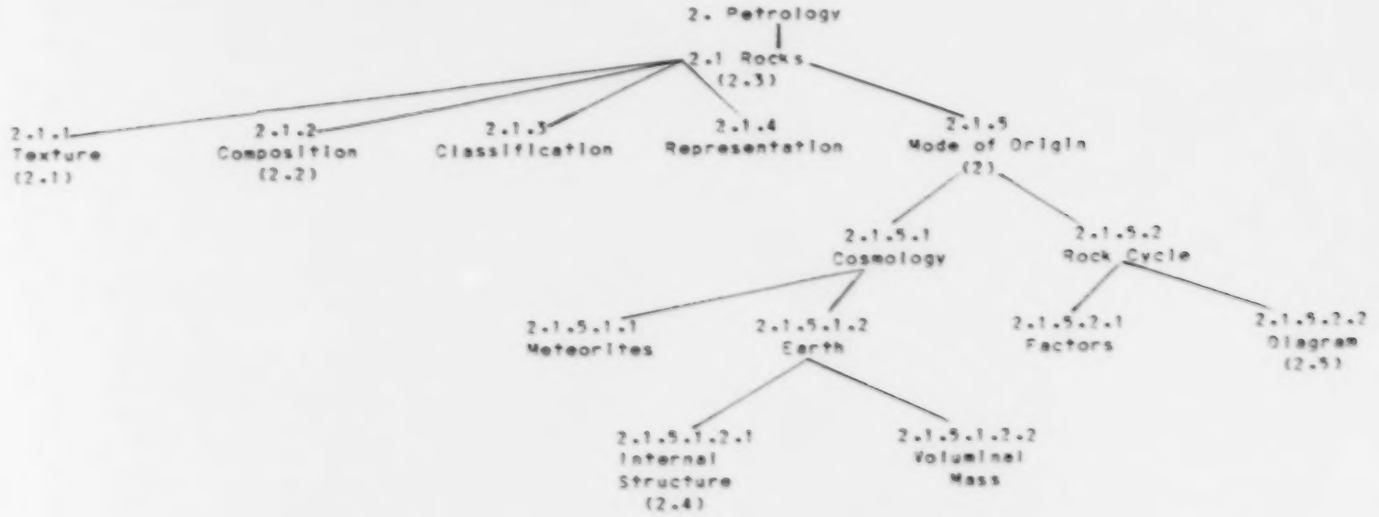
4.3.1 General Objective

2- TO UNDERSTAND the origin of rocks.

4.3.2 Orientation

Petrology is related to geology as physiology is related to biology. By studying the composition of a rock, a geologist can explain the details of its origin and establish the relationships which exist between the different rocks forming the outer layers of the Earth's crust and the upper mantle.

4.3.3 Content Structure



4.3.4 Learning Objectives

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 2.1 **To determine** the texture of a rock at a rock outcrop and from a sample (B.3).	Texture	Measuring	Investigative approach Respect
a) **To determine** the size of the grain of the different components of a rock at a rock outcrop (B.3).	Size of grain	Measuring	Objectivity Respect
b) **To describe** the granular arrangement of the components of a rock at a rock outcrop (B.2).	Granular arrangement	Describing	Objectivity Respect
c) **To describe** the granular form of the components of a rock at a rock outcrop (B.2).	Granular form	Describing	Objectivity Respect
T.O. 2.2 **To determine** the composition of a rock with the naked eye or by using a magnifying glass (B.3).	Composition of a rock	Measuring	Investigative approach
a) **To determine** the characteristics of basic minerals with the naked eye or with the use of a magnifying glass (B.3).	Characteristics of minerals: lustre, fracture, colour, cleavage, hardness, HCl froth (gas bubbles)	Measuring	Self-confidence
b) **To observe** the characteristics of the basic minerals present in a rock with the naked eye or with the use of a magnifying glass (B.1).		Observing	Investigative approach

Learning Objectives	Learning Content		
	Knowledge	**Skills**	**Attitudes**
c) **To identify** the basic minerals present in a rock with the naked eye or with the use of a magnifying glass (D.3).	Basic minerals: silicates, carbonates, oxides and sulfides	Interpreting	Critical spirit Prudence
d) **To determine** the relative content of each on three or four basic minerals present in a rock (B.3).	Relative content	Measuring	Objectivity
*e) **To examine** the properties of organic matter present in a rock with the naked eye or with the use of a magnifying glass (B.1).	Properties of organic matter	Observing	Investigative approach
*f) **To determine** the relative content of organic matter in a rock (B.3).		Measuring	Objectivity
T.O. 2.3 **To identify** rocks by their mineral composition and their texture (D.3).		Interpreting	Critical spirit Prudence
a) **To classify** rocks into three groups on the basis of properties observed at a rock outcrop and from a sample (D.6).	Igneous rocks, sedimentary rocks, metamorphic rocks	Interpreting	Sense of creativity Critical spirit Openness to others Tolerance
b) **To examine** igneous rocks in order to determine their basic properties (texture, mineral composition) (B.1).	Texture, mineral composition	Observing	Investigative approach Respect
c) **To identify** the main types of igneous rocks on the basis of their mineral composition and their texture (D.3).		Interpreting	Critical spirit

* Enrichment objective

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
d) **To examine** sedimentary rocks in order to determine their basic properties (texture, mineral composition, evidence of fossils) (B.1).	Fossils	Observing	Investigative approach Respect
e) **To identify** the main types of sedimentary rocks on the basis of their mineral composition and texture (D.3).		Interpreting	Critical spirit
f) **To examine** metamorphic rocks in order to determine their basic properties (texture, mineral composition) (B.1).		Observing	Investigative approach Respect
g) **To identify** the main types of metamorphic rocks on the basis of their mineral composition and texture (D.3).		Interpreting	Critical spirit
h) **To draw** a geologic map of a given area based on a description of the local rock outcrops (D.1).	Geologic map	Interpreting	Investigative approach Critical spirit
i) **To analyse** a geologic map in order to obtain the information needed to draw a geologic section of a given area (D.3).	Geologic section	Interpreting	Critical spirit
j) **To draw** a geologic section of a given area based on the information provided on a geologic map (D.2 and G.1).		Interpreting Developing dexterity	Investigative approach Self-confidence

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 2.4 **To explain** the inner structure of the Earth on the basis of cosmological data (D.6).	Inner structure of the Earth	Interpreting	Acceptance of the geological method
a) **To measure** the voluminal mass of igneous, sedimentary and metamorphic rocks (B.3 and G.2).	Voluminal mass	Measuring Developing technique	Objectivity Self-confidence Investigative approach
b) **To compare** the voluminal mass of meteorites with that of igneous, sedimentary and metamorphic rocks (C.1 and D.3).		Interpreting Formulating hypotheses	Creative spirit Critical spirit
c) **To construct** a model of the Earth's inner structure based on the voluminal mass of the Earth, of meteorites and of various rocks (E.2).		Constructing a model	Creative spirit
d) **To locate** the elements of the Earth's inner structure on a model (A.1).	Elements of the Earth's inner structure: crust, mantle, core		
T.O. 2.5 **To explain** a diagram of the rock cycle (D.6).	Diagram of the rock cycle	Interpreting	Creative spirit Critical spirit
a) **To explain** the formation of igneous rocks on the basis of various experiments (D.6).	Formation of igneous rocks	Interpreting	Creative spirit Critical spirit
b) **To explain** the formation of sedimentary rocks on the basis of various experiments (D.6).	Formation of sedimentary rocks	Interpreting	Creative spirit Critical spirit
c) **To explain** the formation of metamorphic rocks on the basis of various experiments (D.6).	Formation of metamorphic rocks	Interpreting	Critical spirit Creative spirit

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
d) **To observe** the effects of intervening factors in the rock cycle (B.1).	Effects, intervening factors (rock cycle)	Observing	Investigative approach Objectivity
e) **To name** the major intervening factors in the rock cycle (A.3).	Factors: temperature, pressure, consolidation time, incoming fluids		
f) **To explain** the role of each intervening factor in the rock cycle (D.6).	Role of factors	Interpreting	Critical spirit

4.4 Module 3: Stratigraphy

4.4.1 General Objective

3- TO RECONSTRUCT the chronological order of the geological events that have occurred in a given region.

4.4.2 Orientation

Stratigraphy makes it possible to define the temporal sequence of the geological events of the Earth's history. Stratigraphy has enabled scientists to formulate certain principles concerning relative and absolute chronology (dating). These principles led to the development of a model which explains the chronological order of events that shape the Earth's past.

4.4.3 Content structure

4.4.4 Learning Objectives

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 3.1 **To explain** the sedimentation of a stratum (D.3)		Interpreting	Critical spirit
a) **To observe** a stratum in the field (B.1).	Stratum	Observing	Investigative approach Respect Sense of curiosity
b) **To carry** out the sedimentation of a sand, gravel and clay mixture under various conditions to form a stratum (B.3).	Sedimentation	Measuring	Self-confidence Perseverance
c) **To define** a stratum (A.2).	Stratum		
d) **To observe** the process of sedimentation in the laboratory or in the field (B.1).		Observing	Investigative approach
e) **To define** sedimentation (A.3).	Sedimentation		
f) **To determine** the conditions which contribute to sedimentation (B.3).	Conditions: variations in turbulence, rate of deposition, duration of deposition, variations in direction of flow	Measuring	Investigative approach Self-confidence
T.O. 3.2 **To identify** the major fossil groups in a stratum (D.3).		Interpreting	Critical spirit
a) **To define** a fossil (A.2).	Fossils		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
b) **To observe** fossils in the field (9.1)		Observing	Investigative approach Respect
c) **To define** fossilization (A.3).	Fossilization		
d) **To explain** the process of fossilization (D.6).	Process of fossilization	Interpreting	Creative spirit
*e) **To create** a fossil by using the process of fossilization (G.2).		Developing technique	Self-confidence
f) **To determine** a number of conditions which make fossilization possible (9.3).	Conditions	Measuring	Investigative approach Sense of curiosity
g) **To describe** the major fossil groups which can be found today in the geological formations of Québec (9.7).	Major fossil groups: invertebrates, vertebrates, plants	Describing	Investigative approach Objectivity
h) **To describe** how fossils are used to determine the paleontologic features of a stratum (A.1).	Role of fossils: dating, study of paleontologic environment and of paleontology		
T.O. 3.3 **To describe** the facies of a stratum (9.7)	Facies	Describing	Investigative approach Objectivity
g) **To define** facies (A.3).			

* Optional objective

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
b) **To name** the three types of facies of a stratum (A.2).	Types of facies: continental, marine, mixed		
c) **To describe** the texture of a stratum (B.2).	Texture	Describing	Investigative approach
d) **To define** the petrographic composition of a stratum (A.3).	Petrographic composition		
e) **To determine** the petrographic composition of a stratum (B.3).		Measuring	Investigative approach
f) **To define** sedimentary structures (A.2).	Sedimentary structures: sole marks, mud cracks, ripple marks, crossbedding, graded bedding, stylolites		
g) **To identify** the exposed sedimentary structures on the surface of a stratum (A.1).	Sedimentary structures		
h) **To describe** the lithologic characteristics of a stratum (B.3).	Lithologic characteristics	Measuring	Investigative approach
i) **To define** the paleontologic characteristics of a stratum (A.3).	Paleontologic characteristics: type of fossils, quantity		
j) **To determine** the paleontologic characteristics of a stratum (B.3).		Measuring	Investigative approach

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
k) **To observe** the facies of strata characterized by different lithologic and paleontologic features (B.1).		Observing	Investigative approach
l) **To determine** the facies of a stratum (B.3).		Measuring	Investigative approach
T.O. 3.4 **To determine** the sedimentation cycle of successive strata (D.3).	Sedimentation cycle	Interpreting	Creative spirit Critical spirit
a) **To define** a transgression (A.3).	Transgression		
b) **To describe** the characteristics of a transgression (B.2).	Characteristics of a transgression	Describing	Investigative approach
*c) **To observe,** in the field, the characteristics of a transgression (B.1).		Observing	Investigative approach
d) **To identify, using deduction, a transgression on a geologic map based on the geologic time scale, lithology and structure (D.3).	Geologic time scale	Interpreting	Creative spirit Critical spirit
e) **To define** regression (A.3).	Regression		
f) **To describe** the characteristics of a regression (B.2).	Characteristics of a regression	Describing	Investigative approach
*g) **To observe,** in the field, the characteristics of a regression (B.1).		Observing	Investigative approach

* Optional objective
** Enrichment objective

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
h) **To identify, using deduction, a regression on a geologic map based on the geologic time scale, lithology and structure (D.3).		Interpreting	Critical spirit Creative spirit
T.O. 3.5 **To construct** a geologic time scale based on field observations (B.3 and D.1).		Measuring Interpreting	Perseverance Critical spirit Creative spirit
a) **To define** relative chronology (A.3).	Relative chronology		
b) **To state** the basic principles of relative chronology (A.8).	Law of superposition, Principle of uniformity, Index fossils, Law of crosscutting relationships		
c) **To explain** the basic principles of relative chronology (D.6).		Interpreting	Tolerance, Creative spirit Acceptance of the geological method
d) **To define** the geologic time scale (A.3).	Geologic time scale		
e) **To define** absolute chronology (A.3).	Absolute chronology		

** Enrichment objective

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
f) **To state** the principle of absolute chronology (A.8).	Principle of absolute chronology: absolute dating		
*g) **To list** the various methods used in absolute chronology (A.1).	Methods: uranium-lead, potassium-argon, carbon 14		
h) **To explain** the role of absolute chronology with regard to stratigraphy (D.3).	Role of absolute chronology (in stratigraphy)	Interpreting	Critical spirit
i) **To name** the units of the geologic time scale (A.3).	Units: eon, era, period, epoch		
j) **To use** the geologic time scale to determine the distribution of units on the geologic maps of Québec (F.1, H.3 and D.3).	Geologic time scale	Measuring Interpreting	Self-confidence Critical spirit Investigative approach
*k) **To indicate** the duration of each era of the geologic time scale (A.1).	Duration		
*l) **To name** the main fossil groups associated with each era of the geologic time scale (A.1).	Main fossil groups characteristic of each era		

* Optional objective

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 3.6 **To determine** the direction of a stratum (B.3).	Direction of a stratum	Measuring	Self-confidence Objectivity
a) **To define** the strike of a stratum (A.3).	Strike of a stratum		
b) **To measure** the strike of a stratum (B.3).		Measuring	Self-confidence
c) **To define** the dip of a stratum (B.3).	Dip of a stratum		
d) **To measure** the dip of a stratum (B.3).		Measuring	Self-confidence
e) **To indicate** the conventional symbols that are used to represent the direction of a stratum on a geologic map (A.4).	Conventional symbols		
f) **To designate** the direction of a stratum on a topographic map, using the appropriate conventional symbols (A.4).	Direction of a stratum	Developing technique	
g) **To interpret** the direction of a stratum on a topographic map, using the appropriate conventional symbols (A.4).	Direction of a stratum		

4.5 Module 4: Global Tectonics

4.5.1 General Objective

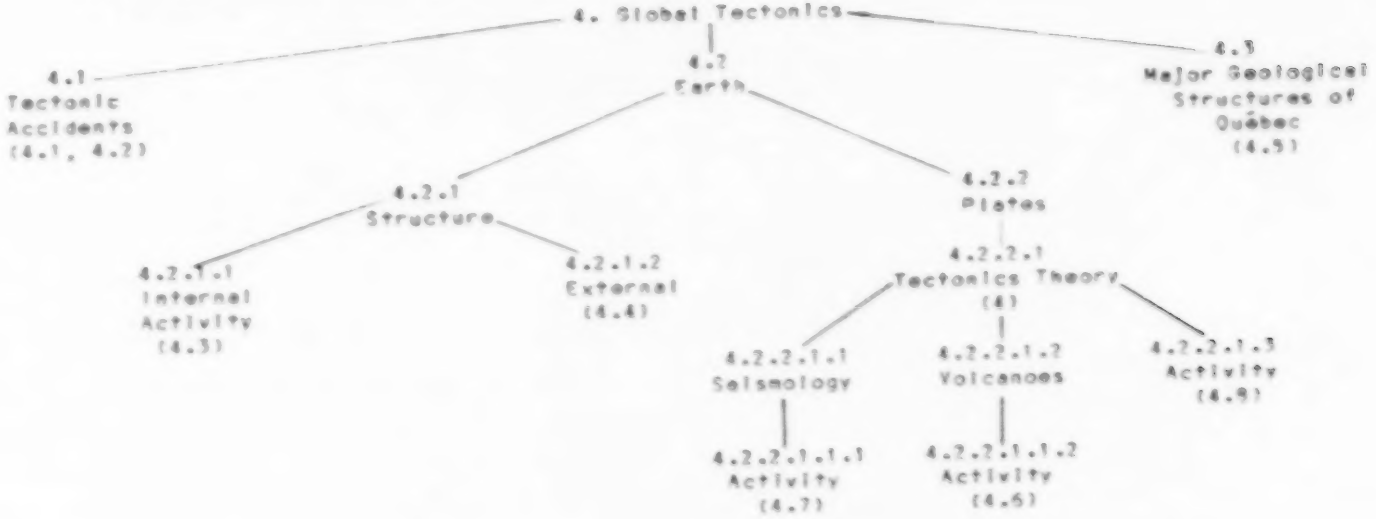
4 - TO UNDERSTAND the theory of plate tectonics.

4.5.2 Orientation

Tectonics is the study of structural deformations that have occurred after the Earth's rocks were formed. These deformations reflect the scope and intensity of the forces that have been operating on Earth since it was first formed. Even in this day and age, certain phenomena serve as a reminder that our planet is still evolving and that its dynamic structure may be explained in terms of the movement of several plates covering the entire Earth's crust.

This explanation will help the student to see that the Earth is a living planet and that geology, like science, tries to explain this energy on the basis of multiple observations and investigations carried out by geologists all over the world.

4.5.3 Content Structure



4.5.4 Learning Objectives

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 4.1 **To explain** the concept of tectonic irregularities on the basis of models and field observations (D.6).	Tectonic irregularities	Interpreting	Creative spirit Critical spirit Objectivity
a) **To observe** a fault, in the field, in order to determine its basic characteristics (B.1).		Observing	Investigative approach
b) **To draw** a fault observed in the field (B.2).		Describing	Self-confidence
c) **To construct** a model of a fault. (E.2 and G.2).		Constructing a model Developing technique	Creative spirit
d) **To define** a fault (A.2).	Fault		
e) **To observe** a fold, in the field, in order to determine its basic characteristics (B.1).		Observing	Investigative approach
f) **To draw** a fold observed in the field (B.2).		Describing	Self-confidence
g) **To construct** a model of a fold (E.2 and G.2).		Constructing a model Developing technique	Creative spirit
h) **To define** a fold (A.2).	Fold		
i) **To construct** a model of an overthrust. (E.2 and G.2).		Constructing a model Developing technique	Creative spirit

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
j) **To observe** an overthrust in the field (B.1).		Observing	Investigative approach
k) **To draw** an overthrust observed in the field (B.2).		Describing	Self-confidence
l) **To define** an overthrust (A.2).	Overthrust		
m) **To construct** a model of a drift (E.2 and G.2).		Constructing a model Developing technique	Creative spirit
n) **To observe** a drift in the field (B.1).		Observing	Investigative approach
o) **To draw** a drift observed in the field (B.2).		Describing	Self-confidence
p) **To define** a drift (A.2).	Drift		
q) **To identify** the possible causes of tectonic irregularities while constructing the models (D.6).	Causes: compression, distension Tectonic irregularities	Interpreting	Critical spirit Creative spirit Objectivity
T.O. 4.2 **To identify** tectonic irregularities on a pair of aerial photographs and on a geologic map (D.3).		Interpreting	Critical spirit
a) **To identify,** using deduction, a fault on a geologic map based on the arrangement of the various rock formations indicated on the map (D.3).		Interpreting	Creative spirit Critical spirit

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
b) **To compare** a fault observed by stereoscopy on a pair of aerial photographs with the way it is represented on a geologic map (D.2).		Interpreting	Critical spirit
c) **To identify,** by deduction, a fold on a geologic map based on the arrangement of the various rock formations indicated on the map (D.3).		Interpreting	Creative spirit Critical spirit
d) **To compare** a fold observed by stereoscopy on a pair of aerial photographs with the way it is represented on a geologic map (D.2).		Interpreting	Critical spirit
e) **To locate** an overthrust on a geologic map by using the geologic time scale of the various rock formations indicated on the map (D.3).		Interpreting	Creative spirit Critical spirit
f) **To deduce** a drift on a geologic map by using the geologic time scale of the various rock formations indicated on the map (D.3).		Interpreting	Creative spirit Critical spirit
T.O. 4.3 **To describe** the Earth's dynamic interior structure (A.3).	Earth's dynamic interior structure		
a) **To define** the lithosphere (A.2).	Lithosphere		
b) **To locate** the lithosphere on a cross section of the Earth (A.1).		Developing technique	
c) **To define** the asthenosphere (A.2).	Asthenosphere		
d) **To locate** the asthenosphere on a cross section of the Earth (A.1).		Developing technique	

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 4.4 **To describe** the Earth's exterior structure (A.3).	Earth's exterior structure		
a) **To locate** shields on a map of the world (A.1).	Shields		
b) **To describe** the relief of a shield using field data, slides or topographic maps (B.2 and D.3).		Observing Interpreting	Investigative approach Critical spirit
c) **To locate** mountain ranges on a map of the world (A.1).	Mountain ranges		
d) **To describe** the relief of a mountain range using field data, slides or topographic maps (B.2 and D.3).		Observing Interpreting	Investigative approach Critical spirit
e) **To locate** mid-ocean ridges on a map of the world (A.1).	Mid-ocean ridges		
f) **To describe** the relief of a mid-ocean ridge, using slides or bathymetric maps (B.2 and D.3)		Observing Interpreting	Investigative approach Critical spirit
g) **To locate** oceanic troughs on a map of the world (A.1).	Oceanic troughs		
h) **To describe** the relief of an oceanic trough using slides or bathymetric maps (B.2 and D.3).		Observing Interpreting	Critical spirit Investigative approach
i) **To locate** astroblemes* on a map of Québec (A.1).	Astrobleme		

* An ancient erosional scar on the Earth's surface, produced by the impact of a cosmic body and usually characterized by a circular outline and highly disturbed rocks showing evidence of intense shock; an eroded remnant of a meteoric or cometary impact crater.[1]

1 M. Gary, R. McAsee and Carol Wolf, **Glossary of Geology** (Washington: American Geological Institute, 1972), p.43.

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
j) **To describe** the relief of an astrobleme using topographic maps and/or slides (D.3).		Interpreting	Critical spirit Investigative approach
T.O. 4.5 **To describe,** using topographic and geologic maps, the major geologic structures of Québec (D.3).		Interpreting	Critical spirit
a) **To name** the major geologic structures of Québec (A.1).	Major structures of Québec: Canadian Shield, Appalachian Mountains, St.Lawrence Lowlands		
b) **To locate** the Canadian Shield on a map of Québec (A.1).	Canadian Shield		
c) **To describe** the Canadian Shield in terms of its lithological and structural features (D.3).		Interpreting	Critical spirit
d) **To locate** the Appalachian Mountains on a map of Québec (A.1).	The Appalachians		
e) **To describe** the Appalachians in terms of their lithological and structural features (D.3).		Interpreting	Critical spirit
f) **To locate** the St. Lawrence Lowlands on a map of Québec (A.1).	St. Lawrence Lowlands		
g) **To describe** the St. Lawrence Lowlands in terms of their lithological and structural features (D.3).		Interpreting	Critical spirit
T.O. 4.6 **To describe** the activity of a volcano, using a model (D.6 and E.2).	Activity of a volcano	Interpreting Constructing a model	Creative spirit Critical spirit
a) **To define** a volcano (A.2).	Volcano		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
b) **To observe,** on film, the different kinds of emissions of an erupting volcano (B.1).	Kinds of emissions: lava, gas	Observing	Investigative approach
c) **To describe** the structure of a surface volcano, using slides or film (B.2).	Structure of a surface volcano	Describing	Investigative approach
d) **To describe** the structure of a submarine volcano, using slides or film (B.2).	Structure of a submarine volcano	Describing	Investigative approach
T.O. 4.7 **To describe** how an earthquake occurs, using a model (D.6 and E.2).	How an earthquake occurs	Interpreting Constructing a model	Creative spirit Critical spirit
a) **To define** an earthquake (A.2).	Earthquake		
b) **To determine** the epicentre of an earthquake on the basis of data obtained from three (3) seismographs (B.3).	Epicentre of an earthquake	Measuring	Self-confidence
c) **To define** the hypocentre of an earthquake (A.3).	Hypocentre of an earthquake		
d) **To observe** the vertical movements of different voluminal-mass materials (B.1).	Vertical movements: isostasy	Observing	Investigative approach
e) **To describe** the major causes of earthquakes (A.9).	Causes: tangential and vertical shifts		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
f) **To observe** the tangential shifts of materials being pushed against each other (B.1).	Tangential shifts: distension, compression	Observing	Investigative approach
g) **To compare** the scales used for measuring the intensity of an earthquake (D.2).	Measuring scales: Mercalli, Richter	Interpreting	Critical spirit
*h) **To identify** the consequences of earthquakes in populated areas (D.6).	Consequences of an earthquake	Interpreting	Creative spirit Openness towards others Critical spirit
T.O. 4.8 **To describe,** using a model, the plate tectonics theory (A.9 and E.2).	The plate tectonics theory	Developing a theory	Creative spirit Critical spirit
a) **To locate** earthquake regions on a map of the world (A.1).	Earthquake		
b) **To locate** volcanoes on a map of the world (A.1).	Volcano		
c) **To locate** the major plates on a map of the world (A.1).	Plates		
d) **To recount** the history of plate tectonics theory (A.1).	History of plate tectonics theory		
e) **To illustrate** the plate tectonics theory, using a model (E.2).	Plate tectonics theory	Developing a theory	Creative spirit

* Optional Objective

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
f) **To describe** the types of movement associated with plate tectonics (A.9).	Types of movement: distension, subduction		
g) **To link** volcanoes to the plate tectonics theory (D.6).		Interpreting	Creative spirit Critical spirit
h) **To link** earthquakes to the plate tectonics theory (D.6).		Interpreting	Creative spirit Critical spirit
i) **To name** the effects of movements associated with plate tectonics (A.1).	Effects of movements associated with plate tectonics: formation of mountain ranges and oceans		

4.6 Module 5: Natural Resources

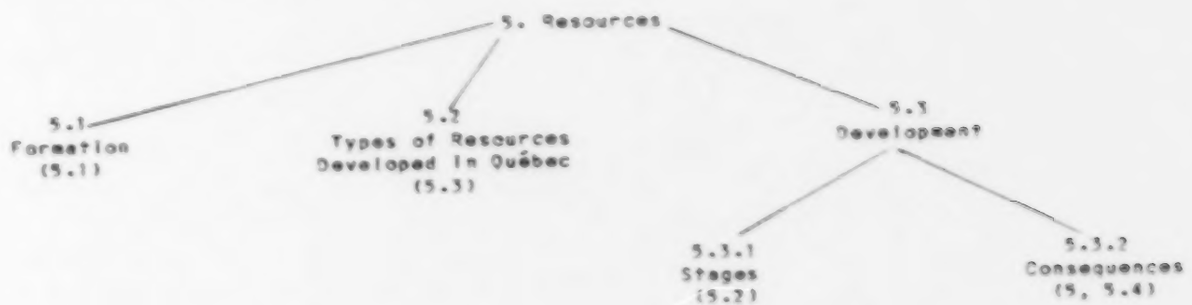
4.6.1 General Objective

5 - TO UNDERSTAND, from a mesological perspective, the consequences of resource development.

4.6.2 Orientation

One aspect of the work of a geologist involves prospecting for new deposits; in fact, mining companies sometimes hire geologists to supervise their mining operations. Workable resources may be classified into four basic categories: metallic substances, industrial minerals, building materials and fossil fuels. The task of prospecting for natural deposits must be guided by knowledge of the local geology and of the conditions under which these deposits formed. To use of non-renewable resources must take certain factors into account, such as the conditions met at different stages of resource development and the consequences of exploitation with respect to the natural environment, the development of the region and national development.

4.6.3 Content Structure



4.6.4 Learning Objectives

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 5.1 **To explain** the formation of natural resources using a diagram of the rock cycle (D.6).	Formation of natural resources	Interpreting	Creative spirit Critical spirit Objectivity
a) **To define** metallic substances (A.2).	Metallic substances		
b) **To describe** the formation of metallic substances in terms of the formation of detrital and chemical sedimentary rock, metamorphic rock and igneous rock.	Formation of metallic substances	Interpreting	Creative spirit Critical spirit Objectivity
c) **To define** industrial minerals (A.2).	Industrial minerals		
d) **To describe** the formation of industrial minerals in terms of the formation of chemical, bio-chemical and consolidated detrical sedimentary rock, metamorphic rock and igneous rock (D.6).	Formation of industrial minerals	Interpreting	Creative spirit Critical spirit Objectivity
e) **To define** building materials (A.2).	Building materials		
f) **To describe** the formation of building materials in terms of the formation of detrital and chemical sedimentary rock, metamorphic rock, and igneous rock (D.6).	Formation of building materials	Interpreting	Creative spirit Critical spirit Objectivity
g) **To define** fossil fuels (A.2).	Fossil fuels		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
h) **To describe** the formation of fossil fuels in terms of the formation of biochemical sedimentary rock (D.6).	Formation of fossil fuels	Interpreting	Creative spirit Critical spirit Objectivity
T.O. 5.2 **To describe** the different stages in the development of non-renewable resources (A.7).			
a) **To name** the different stages of resource development (A.2).	Stages of resource development: prospecting, development studies, mining		
b) **To state** the purpose of each stage of resource development (A.1).	Purpose of each stage of development		
c) **To name** the stages in the prospecting for mineral deposits (A.2).	Stages of prospecting: large-scale and small-scale explorations		
d) **To describe** large-scale explorations (A.7).	Large-scale exploration		
e) **To describe** small-scale explorations (A.7).	Small-scale exploration		
f) **To name** the stages involved in the development studies of mineral deposits (A.2).	Stages of development studies: development operations, evaluation of reserves, feasibility studies, decision-making regarding mining		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
g) **To describe** the factors considered in conducting development studies for mineral deposits (A.6).	Factors: nature of mineralization, size, depth and geographic location of deposit, market conditions		
h) **To name** the different stages in mining an ore body (A.1).	Stages of mining: mine development, mining		
i) **To describe** the factors considered before mining an ore body (A.6).	Factors: nature of mineralization, size, depth and geographic location of deposit, market conditions		
T.O. 5.3 **To describe** the kinds of resources that are developed in Québec (A.6).	Kinds of resources developed in Québec		
a) **To name** the basic metallic substances (A.2).	Metallic substances		
b) **To locate,** on a geologic map of the province, the regions which produce basic metallic substances (A.1).	Regions producing metallic substances		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
c) **To link** basic metallic substances with the main types of rocks found in the metal-producing regions (D.3).		Interpreting	Creative spirit
d) **To describe** the metallurgic processing of basic metallic substances (A.7).	Metallurgic processing of metallic substances		
e) **To describe** the uses of basic metallic substances (A.1).	Uses of metallic substances		
f) **To describe** the importance of basic metallic substances with respect to the mining industry of Québec (A.6).	Importance of metallic substances		
g) **To name** the basic industrial minerals (A.2).	Industrial minerals		
h) **To locate,** on a geologic map of Québec, the regions which produce basic industrial minerals (A.1).	Regions producing industrial minerals		
i) **To link** basic industrial minerals with the main types of rocks found in the producing regions (D.3).		Interpreting	Creative spirit
j) **To describe** the uses of basic industrial minerals (A.1).	Uses of industrial minerals		
k) **To describe** the importance of basic industrial minerals with respect to production in Québec (A.6).	Importance of industrial minerals		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
l) **To name** the basic building materials (A.2).	Building materials		
m) **To locate,** on a geologic map of Québec, the regions which produce basic building materials (A.1).	Regions producing building materials		
n) **To link** basic building materials with the main types of rocks found in Québec's producing regions (D.3).		Interpreting	Creative spirit
o) **To describe** the uses of basic building materials (A.1).	Uses of building materials		
p) **To describe** the importance of basic building materials with respect to production in Québec (A.5).	Importance of building materials		
q) **To name** the basic fossil fuels (A.2).	Fossil fuels		
r) **To locate,** on a geologic map of the province, the regions which produce basic fossil fuels (A.1).	Regions producing fossil fuels		
s) **To link** basic fossil fuels with the main types of rocks found in the producing regions (D.3).		Interpreting	Creative spirit
t) **To describe** the uses of basic fossil fuels (A.1).	Uses of fossil fuels		
u) **To describe** the importance of basic fossil fuels with respect to production in Québec and Canada (A.5).	Importance of fossil fuels		

Learning Objectives	Learning Content		
	Knowledge	Skills	Attitudes
T.O. 5.4 **To evaluate** the consequences of resource development (D.3).		Interpreting	Critical spirit Responsibility Prudence
a) **To determine** the consequences of resource development for the natural environment (D.3, A.10, F.2).		Interpreting	Creative spirit
b) **To choose** the consequences of resource development that are least harmful to the natural environment (1.5 and 4.3).	Least harmful consequences for the natural environment		Responsibility
c) **To determine** the consequences of resource development for the development of a region (D.3, A.10, F.2).		Interpreting	Creative spirit
d) **To choose** the consequences of resource development that are most favourable for the development of a region (1.5 and 4.3).	Most favourable consequences for the development of the region		Responsibility
e) **To determine** the consequences of resource development for national development (D.3, A.10, F.2).		Interpreting	Creative spirit
f) **To choose** the consequences of resource development that are most favourable for national development (1.5 and 4.3).	Most favourable consequences for national development		Responsibility

5. EVALUATION

In the glossary of the Manuals on Educational Evaluation (16-7265A), educational evaluation is defined as a process which comprises:

a) gathering, organizing, and interpreting (measurement) information;
b) making judgments; giving an opinion on the learning of the student;
c) deciding on a course of action (decision) based on the established evaluation objectives; making a choice among various courses of action related to learning progress or to recognition of learning achievements.[1]

5.1 Measurement

In the Geology program, measurement applies to scholastic performance and includes knowledge (comprehension), skills (techniques) and attitudes (interests), the three areas prescribed by the learning objectives.

5.1.1 Selection of Measurement Instruments

Examples of the different types of measurement instruments referred to in the following paragraphs will be provided in the curriculum guide to this program.

. Knowledge: Knowledge includes comprehension and application (categories A and F in Bloom, Hastings and Madaus' taxonomy of educational objectives) and can be measured by using either objective or subjective tests or, depending on the circumstances, a combination of the two.

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[1] Québec, ministère de l'Éducation, **Manuals on Educational Evaluation; Manual Two: Glossary** (Code 16-7265A) (Québec: ministère de l'Éducation, 1987), pp. 8, 10, 15, 17.

. Skills: Skills can be measured by using objective or subjective tests (categories C, D, and E in Bloom, Hastings and Madaus' taxonomy of educational objectives), assessment sheets (categories B and G), or laboratory or field trip reports (categories B, D and E).

. Attitudes: Attitudes related to interests (categories H and I in Bloom, Hastings and Madaus' taxonomy of educational objectives) can be measured by using either assessment sheets or attitude scales.

5.1.2. Quality of Measurement Instruments

A measurement instrument's most important quality is its validity; in other words, it should measure what it is supposed to measure.

> Content validity... is the degree to which the content of the instrument represents what should be evaluated, that is, specific learning based on a set program, and/or affective traits, and/or well defined psychomotor abilities. This validity is determined by means of a detailed analysis of the instrument's content done by experts in the subject matter (sic).[1]

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[1] Québec, ministère de l'Éducation, **Manuals on Educational Evaluation; Manual Two: Glossary**, p.33.

5.1.2 (cont'd)

In developing any measurement instrument, it is important that the questions always correspond to the learning objectives being measured. When measuring terminal learning objectives at the end of one or several modules, the content validity should be established by using a table of specifications.

5.2 Criterion-Referenced and Norm-Referenced Evaluation

Evaluation consists of any activity which attempts to analyze and to interpret the scores and indicators obtained through measurement in order to help the educator make the best possible decisions about the student's progress. In other words, in evaluation, a value or a score is assigned by comparing a result to a norm or a criterion. In this case, the criterion is the program, and the norm is represented by the group of students. This involves two kinds of evaluation, depending on the frame of reference (i.e., the norm or the criterion):

- criterion-referenced evaluation is used to establish how much the student has learned with respect to the objectives of the program;

- norm-referenced evaluation is used to compare the student's performance with that of the group.

Criterion-referenced evaluation will be used for the intermediate and terminal learning objectives in order to evaluate the student's progress and to take appropriate remedial action if necessary. Norm-referenced evaluation will be used for the terminal learning objectives for purposes of classification and certification of studies.

APPENDIX

BLOOM, HASTINGS AND MADAUS' TAXONOMY OF SPECIFICATIONS FOR SCIENCE EDUCATION[1]

A- Knowledge and comprehension

- A-1 KNOWLEDGE OF SPECIFIC FACTS
- A-2 KNOWLEDGE OF SCIENTIFIC TERMINOLOGY
- A-3 KNOWLEDGE OF CONCEPTS OF SCIENCE
- A-4 KNOWLEDGE OF CONVENTIONS
- A-5 KNOWLEDGE OF TRENDS AND SEQUENCES
- A-6 KNOWLEDGE OF CLASSIFICATIONS, CATEGORIES AND CRITERIA
- A-7 KNOWLEDGE OF SCIENTIFIC TECHNIQUES AND PROCEDURES
- A-8 KNOWLEDGE OF SCIENTIFIC PRINCIPLES AND LAWS
- A-9 KNOWLEDGE OF THEORIES OR MAJOR CONCEPTUAL SCHEMES
- A-10 IDENTIFICATION OF KNOWLEDGE IN A NEW CONTEXT
- A-11 TRANSLATION OF KNOWLEDGE FROM ONE SYMBOLIC FORM TO ANOTHER

B- Process of scientific inquiry: Observing and measuring

- B-1 OBSERVATION OF OBJECTS AND PHENOMENA
- B-2 DESCRIPTION OF OBSERVATIONS USING APPROPRIATE LANGUAGE
- B-3 MEASUREMENT OF OBJECTS AND CHANGES
- B-4 SELECTION OF APPROPRIATE MEASUREMENT INSTRUMENTS
- B-5 ESTIMATION OF MEASUREMENTS AND RECOGNITION OF LIMITS IN ACCURACY

C- Processes of scientific inquiry: Seeing a problem and seeking ways to solve it

- C-1 RECOGNITION OF A PROBLEM
- C-2 FORMULATION OF A WORKING HYPOTHESIS
- C-3 SELECTION OF SUITABLE TESTS OF A HYPOTHESIS
- C-4 DESIGN OF APPROPRIATE PROCEDURES FOR PERFORMING EXPERIMENTS

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[1] B.S. Bloom, J.T. Hastings and George F. Madaus, **Handbook on Formative and Summative Evaluation of Student Learning** (New York: McGraw-Hill Inc., 1971), p. 562.

D- Processes of scientific inquiry: Interpreting data and formulating generalizations

- D-1 PROCESSING OF EXPERIMENTAL DATA
- D-2 PRESENTATION OF DATA IN THE FORM OF FUNCTIONAL RELATIONSHIPS
- D-3 INTERPRETATION OF EXPERIMENTAL DATA AND OBSERVATIONS
- D-4 EXTRAPOLATION AND INTERPOLATION
- D-5 EVALUATION OF A HYPOTHESIS UNDER TEST IN THE LIGHT OF DATA OBTAINED
- D-6 FORMULATION OF GENERALIZATIONS WARRANTED BY RELATIONSHIPS FOUND

E- Processes of scientific inquiry: Building, testing, and revising a theoretical model

- E-1 RECOGNITION OF THE NEED FOR A THEORETICAL MODEL
- E-2 FORMULATION OF A THEORETICAL MODEL TO ACCOMMODATE KNOWLEDGE
- E-3 SPECIFICATION OF RELATIONSHIPS SATISFIED BY A MODEL
- E-4 DEDUCTION OF NEW HYPOTHESES FROM A THEORETICAL MODEL
- E-5 INTERPRETATION AND EVALUATION OF TESTS OF A MODEL
- E-6 FORMULATION OF A REVISED, REFINED, OR EXTENDED MODEL

F- Application of scientific knowledge and methods

- F-1 APPLICATION TO NEW PROBLEMS IN THE SAME FIELD OF SCIENCE
- F-2 APPLICATION TO NEW PROBLEMS IN A DIFFERENT FIELD OF SCIENCE
- F-3 APPLICATION TO PROBLEMS OUTSIDE OF SCIENCE (INCLUDING TECHNOLOGY)

G- Manual skills

- G-1 DEVELOPMENT OF SKILLS IN USING COMMON LABORATORY EQUIPMENT
- G-2 PERFORMANCE OF COMMON LABORATORY TECHNIQUES WITH CARE AND SAFETY

H- Attitudes and interests

- H-1 MANIFESTATION OF FAVOURABLE ATTITUDES TOWARD SCIENCE AND SCIENTISTS
- H-2 ACCEPTANCE OF SCIENTIFIC INQUIRY AS A WAY OF THOUGHT
- H-3 ADOPTION OF "SCIENTIFIC ATTITUDES"
- H-4 ENJOYMENT OF SCIENCE LEARNING EXPERIENCES
- H-5 DEVELOPMENT OF INTERESTS IN SCIENCE AND SCIENCE-RELATED ACTIVITIES
- H-6 DEVELOPMENT OF INTEREST IN PURSUING A CAREER IN SCIENCE

I- Orientation

- I-1 RELATIONSHIPS AMONG VARIOUS TYPES OF STATEMENTS IN SCIENCE
- I-2 RECOGNITION OF THE PHILOSOPHICAL LIMITATIONS AND INFLUENCE OF SCIENTIFIC INQUIRY
- I-3 HISTORICAL PERSPECTIVE: RECOGNITION OF THE BACKGROUND OF SCIENCE
- I-4 REALIZATION OF THE RELATIONSHIPS AMONG SCIENCE, TECHNOLOGY AND ECONOMICS
- I-5 AWARENESS OF THE SOCIAL AND MORAL IMPLICATIONS OF SCIENTIFIC INQUIRY AND ITS RESULTS